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ABSTRACT

The relative effectiveness of three methods of teaching fraction computation in the context of the community college was investigated. The use of calculators was a special focus of the study. The three methods were: (1) conventional algorithms with no calculator, (2) conventional algorithms with calculator, and (3) alternative algorithms using decimal fractions with the calculator. The results indicate that learning calculator-based algorithms produced no differences in computational skill, understanding, attitudes, nor length of time to learn when compared with learning conventional algorithms. (MP)

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Fractions Pose Problems for Students

The difficulties students have had with fraction computation algorithms have led to various studies. In a summary of research in arithmetic, Wilson (1950) discussed studies which listed from 178 to 261 unit skills or problem types in addition, subtraction, multiplication, and division of fractions, one of the factors which contributes to student difficulty with fraction algorithms. He stated that

> Studies have revealed a large amount of error and confusion even when the tests were limited to simple fractions within the limits of adult usage. . . It seems clear that few pupils understand the calculation processes with fractions (p. 52).

More recently, the National Assessment of Educational Progress results have born out the same conclusion that "many pupils are incorrectly applying the algorithms for operating with fractions (Carpenter, Coburn, Reyes, and Wilson, 1975, p. 442).

Community college students often lack skill in operating with fractions as is evidenced by the inclusion of the topic in basic arithmetic texts for developmental mathematics courses. The teaching approach usually taken is a re-explanation of conventional algorithms which students have already encountered in elementary school. The increasing availability of the hand-held calculator

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raises the question of how much emphasis should be placed on these conventional algorithms. This paper reports on a study conducted in an attempt to provide some answers to questions about instruction on computation with fractions in the context of the community college. The use of calculators was a special focus of the study.

What Students Don't Know about Fractions

A side aspect of the study was a preliminary error analysis of student responses to the Stanford Diagnostic Arithmetic Test subtests of Common Fraction Understanding and Computation. One third of the students incorrectly listed the fraction representing the shaded portion of a circle. Over half the students were unable to identify the fractional part of a unit line segment. Such errors would lead one to conclude that these students would have difficulty interpreting circle graphs and using a ruler to measure in sixteenths. Two thirds of the students were unable to reduce a common fraction involving 17 as the GCD of its numerator and denominator. A common error in addition of fractions was the incorrect algorithm,

$$\frac{a}{b} + \frac{c}{d} = \frac{a+c}{b+d}.$$

In subtraction of fractions, mixed numbers led to difficulties. Typical errors were as follows:

$$\begin{array}{rr} 3 & 5\ 1/3 \\ -1\ 1/4 & -\ 2/3 \\ \hline 2\ 1/4 & 5\ 1/3 \end{array}$$

In the example on the left, it appears that students simply brought down the fractional part of the mixed number while subtracting the whole number parts. In the example on the right, the students probably subtracted the smaller fractional

part from the larger. A similar incorrect algorithm is often employed in whole number subtraction by students who do not understand borrowing or regrouping and thus write that 22-8 = 26 since 2 from 8 is 6.

One can surmise the incorrect algorithms which led to errors similar to the following for over half the students:

$$1/3 \times 8 = \frac{8}{24}$$

$$3 \times 4\tfrac{1}{2} = 12\tfrac{1}{2}$$

$$1\ 4/5 \times 3/4 = 1\ 12/20$$

$$2\tfrac{1}{2} \times 4\ 1/3 = 8\ 1/6$$

Failing to invert the divisor in fraction division or inverting the dividend produced incorrect answers for the majority of students. Since usual fraction algorithms are so imperfectly remembered by developmental students at the community colleges studied, the question was asked whether calculator-based algorithms would be a viable alternative.

The Research Study

The purpose of this study was to determine the relative effectiveness of three methods of teaching fraction computation. In the first method, a conventional algorithm set was used in which computation was performed according to "usual" text approaches. In the second method of instruction, students were instructed on how to use a calculator and to compute using the conventional algorithms. The third method involved an alternative algorithm set in which each fractional operand was converted to a decimal on a calculator (truncated to thousandths). The indicated operation was then performed on the numbers in decimal form on the calculator. To determine the relative effectiveness of the three methods of teaching fraction computation, measures of fraction computation skill, fraction understanding, and attitude towards mathematics were taken on groups of community college students who received the different instructional methods.

Students enrolled in developmental arithmetic courses at two community colleges in Tennessee were randomly assigned to treatment groups representing the three instructional methods. The three instructional methods were embodied in modularized slide-tape-workbook presentations which students studied at their own pace. Treatment group one used commercially available materials which have been used for several years at both colleges. These materials use a conventional algorithm set. Treatment group two used the same materials plus an experimenter made unit on operating a calculator. Treatment group three used experimenter made units on operating a calculator and computing with fractions using a calculator-based algorithm set.

Demographic data were collected on the students. A measure of initial computational ability was taken using the Adult Basic Learning Examination, Level III, Arithmetic. Pre- and post-treatment measures of fraction computation, fraction understanding, and attitude toward mathematics were made using two subtests of the Stanford Diagnostic Arithmetic Test, Level II, and the Aiken Revised Math Attitude Scale. Data were collected on the length of time each student took to complete the treatment. Useful data were collected on 48 students at one college and 33 at the other.

MANOVA with repeated measures was used with fraction computation, fraction understanding, and attitude towards mathematics as dependent variables. The repeated measures aspect of the design consisted of pretest and posttest scores. Means, standard deviations, and univariate ANOVAs were reported on the other data. The findings were

1. There were no significant differences among the three treatment groups on mean scores for fraction computation, fraction understanding, and attitude towards mathematics.

2. There was a significant difference between pretest and posttest mean scores for fraction computation, fraction understanding, and attitude towards mathematics. A discriminate analysis follow-up procedure yielded a discriminate function. The relative sizes of its standardized coefficients were indications that most of the gain from pretests to posttests could be attributed to the dependent variable of fraction computation.
3. There were no significant differences among treatment groups in number of days to complete the treatment. It was concluded that community college students can appreciably increase their skill in fraction computation in a relatively short period of time, on an average of three weeks.

Specifically, on an average all treatment groups increased from 59% to 77% correct on the understanding subtest and from 41% to 80% on the computation subtest of the SDAT. The instructional methods used in this study had less effect on attitude towards mathematics and fraction understanding. Learning calculator-based algorithms, which were new to the students, produced no differences in computational skill, understanding, attitudes, nor length of time to learn when compared with learning conventional algorithms.

Some Observations for the Classroom Teacher

Some students in the calculator-based algorithm group resisted using the calculator algorithms even though they had agreed to participate in the study. Twenty-five percent of the students in that group left all of their posttest answers in common fraction form indicating that they had ignored the calculator algorithms. It would appear that some developmental students are wary of new approaches.

Two additional observations about student behavior were made. It was observed that some students were not careful about the order of entering numbers in subtraction. For example, in 1/4 - 1/5 the computation might be done as 1 ÷ 5 - 1 ÷ 4 or .2 - .25 to obtain -.05. The students then ignored the negative sign to record the answer as .05. This error was mentioned in the written material, but stressed in the slide presentation. The same error of entering numbers in an improper order occurred then in division of fractions. However, these quotients were marked incorrect since the correct answers were the reciprocals of the quotients obtained. It is a common characteristic of developmental studies students to be careless in correcting homework and self-tests. Classroom procedure should involve periodic teacher-scored tests followed by reteaching for students who are careless in this way.

The second observation with regard to treatments had to do with the length of the calculator algorithms. The shortest algorithms possible in terms of explanation involve converting each fraction to a decimal, writing each fraction on paper, and then re-entering each decimal to perform the calculation. The most efficient algorithms in terms of calculator use involve storage of intermediate results in memory. As the experimenter wrote the instructional materials, it was decided to make some use of memory for storage of intermediate results an optional part of the algorithms. It appears that some of the weaker students who should have used the non-memory algorithms attempted to use the memory algorithms unsuccessfully. This observation brought home the fact that though calculators are often seen as a blessing for the weaker student, it is the student with a more sophisticated understanding of arithmetic and algebraic properties that can make the most use of calculators. Several recent articles have spoken to a need for special skills in algebra and algebraic notation for efficient calculator use (Ducharme, 1978; Leitzel and Waits, 1976; Schultz, 1978).

The Use of Fractions

The focus of this paper has been on computational algorithms. Knowledge of these algorithms serves no purpose if the student does not know when to use the algorithms. It has been observed that developmental students commonly fail to distinguish when to multiply and when to divide in problems such as the following:

> Some decorations require 2/3 yard of ribbon. How many can be cut from 6 yards?
>
> A batch of cookies takes 2/3 cup of sugar. How much sugar is needed for 5 batches?
>
> One type of rocket carries 3/4 ton of equipment. A newer rocket carries 6 tons. How many of the first rocket can be replaced by one new rocket?

It is important to integrate problems which require the student to distinguish what operation needs to be performed throughout the teaching of fraction algorithms, whether conventional or calculator-based. Otherwise, the student learns algorithms they will be unable to apply.

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